

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Proposed Revisions to Advisory Circular 25-7A, Flight Test Guide for Certification of Transport Category Airplanes.

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice of proposed advisory circular and request for comments.

SUMMARY: This notice requests comments regarding proposed revisions to Advisory Circular (AC) 25-7A, "Flight Test Guide for Certification of Transport Category Airplanes." AC 25-7A provides guidance on acceptable means, but not the only means, of demonstrating compliance with the airworthiness standards for transport category airplanes. The proposed revisions harmonize, expand, and clarify existing advisory material concerning certain airplane performance requirements to address inconsistencies in the means of compliance with the existing airworthiness standard and to reflect increased knowledge of airplane and propulsion system performance modeling and test verification practices since the standard was established. This notice provides interested persons an opportunity to comment on the proposed revisions to AC 25-7A.

DATES: Your comments must be received on or before [insert date 60 days after date of publication]

ADDRESSES: You should send your comments on the proposed AC revisions to the Federal Aviation Administration, Attention: Don Stimson, Airplane & Flight Crew Interface Branch, ANM-111, Transport Airplane Directorate, Aircraft Certification

Service, 1601 Lind Ave SW., Renton, WA 98055-4056. You may examine comments at this address between 7:30 a.m. and 4:00 p.m. weekdays, except Federal holidays.

FOR FURTHER INFORMATION CONTACT: Don Stimson, Airplane & Flight Crew Interface Branch, ANM-111, at the above address, telephone 425-227-1129, or facsimile 425-227-1320.

SUPPLEMENTARY INFORMATION:

Comments Invited

You are invited to comment on the proposed revisions to AC 25-7A by submitting such written data, views, or arguments as you may desire. You should identify the title of the AC and submit your comments in duplicate to the address specified above. The Transport Airplane Directorate will consider comments received on or before the closing date for comments before issuing the revision to AC 25-7A. You may view the complete text of AC 25-7A at the following Internet address:

<http://www.faa.gov/avr/air/airhome.htm> at the link titled “Advisory Circulars” under the “Available Information” drop-down menu.

Discussion

Harmonization of Standards and Guidance

The following proposed revisions to AC 25-7A are based on a recommendation that the Aviation Rulemaking Advisory Committee (ARAC) submitted to the FAA. The FAA tasked ARAC (63 FR 50954, September 23, 1998) to provide advice and recommendations on “harmonizing” certain sections of part 25 (including 25.101(c)) with the counterpart standards contained in Joint Aviation Requirements (JAR) 25. The goal of “harmonization tasks” such as this is to ensure that:

- where possible, standards and guidance do not require domestic and foreign parties to manufacture or operate to different standards for each country involved; and
- the standards and guidance adopted are mutually acceptable to the FAA and the foreign aviation authorities.

What are the Differences in the FAA and JAA standards or policy and what do these differences result in?

In the case of § 25.101(c), the FAA and JAA standards are the same. The differences are in the policies and certification approval practices relative to altitude/temperature extrapolation of takeoff performance data.

In general, both FAA and JAA policy is to limit the unrestricted extrapolation of takeoff data to 6,000 feet above the altitude at which the takeoff performance data are obtained. For further extrapolations, a takeoff distance penalty of 2 percent must be applied for each 1,000 feet of extrapolation beyond the 6,000-foot limit. For the FAA, a further constraint is that engine data may only be extrapolated 3,000 feet above the altitude at which specific engine data have been obtained to verify takeoff thrust models.

For the JAA, a 2 percent takeoff distance penalty must also be applied for every 5°C of temperature extrapolation beyond a temperature that exceeds either:

- a temperature 15°C higher than the maximum temperature tested; or
- the amount by which the maximum temperature tested exceeds the minimum temperature tested.

The FAA does not apply extrapolation limits for temperature. Instead, the FAA policy is to require engine limits compliance to be demonstrated by airplane testing at a

sea level ambient temperature near the highest temperature for which the engine is flat-rated. In addition, to allow higher altitude data extrapolation, the use of engine power setting overboost will generally provide higher temperature conditions (i.e., closer to the flat-rated highest temperature) at the simulated altitude.

Since these policies represent only one means of compliance with the regulatory standards, the criteria noted above have not always been strictly applied. For example, experience from previous certification programs, combined with thorough substantiation of an acceptable model of engine thrust and lapse rate characteristics, has been used to allow extrapolations beyond 6,000 feet above the highest altitude tested without applying a conservative factor. In the same vein, the 3,000-foot extrapolation limit on engine data has not always been applied.

Considerably more experience has since been gained both in terms of modeling airplane and propulsion system (turbine engines and propellers, where appropriate) performance and in verifying the accuracy of these models for determining high (and low) altitude takeoff and landing performance. This experience has shown that the soundness of the extrapolation is primarily a function of the accuracy of the propulsion system performance model and its integration with the airplane drag model. The basic aerodynamic characteristics of the airplane do not change significantly with altitude or ambient temperature, and any such effects are readily taken into account by standard airplane performance modeling practices.

The effect of the proposed changes to the acceptable means of compliance that is proposed to replace the current guidance material in AC 25-7A would be to allow

extrapolation of airplane takeoff and landing performance data to higher and lower altitudes without applying an arbitrary distance penalty if the following criteria are met:

- A comprehensive propulsion system model is developed covering the entire operational envelope and substantiated by inflight thrust measurement
- Lapse rate takeoff testing to characterize the behavior of power setting, rotor speeds, propeller effects (i.e., torque, RPM, and blade angle), or gas temperature as a function of time, thermal state, or airspeed, as appropriate, is performed at an altitude within 3,000 feet of the maximum approved takeoff airport altitude.
- The combination of the propulsion system performance model and the airplane performance model is validated by the takeoff performance test data, climb performance tests, and tests used to determine airplane drag.
- Proper operation of other systems dependent on altitude is considered for the highest takeoff and landing altitude for which approval is sought.

This proposed methodology is consistent with, but more stringent than, some of the means of compliance that have been accepted in past certification programs. In some previous certification programs, the validation of lapse rate characteristics by takeoff demonstrations has not always been performed at an airport altitude within 3,000 feet of the maximum approved takeoff airport altitude.

This proposed revision to the AC 25-7A guidance material should act as a catalyst to provide more consistency throughout the industry for applying “best practices” in determining and substantiating airplane and propulsion system performance models throughout the operating envelope. Instead of applying an arbitrary takeoff and landing distance penalty for large extrapolations in altitude above the test altitude, this means of

compliance encourages applicants to develop and verify an accurate model of the propulsion system performance and substantiate its integration with the airplane drag model.

Since AC 25-7A only provides one acceptable means of compliance with the regulatory standard, applicants will continue to have the option of proposing the use of another means of compliance.

Dissenting Opinion

One member of the ARAC working group registered the following dissenting position regarding paragraph 3a(8)(v) of the proposed advisory material.

“It is recognized that starting capability for the engines and APU may be relevant to operations at high altitude airports. However, there are no specific FAR/JAR requirements for engine or APU starting capability on the ground, so it is not appropriate to list ground starting capability as relevant to FAR/JAR compliance. It is requested that the references to engine and APU starting capability be deleted from paragraph 3a(8)(v).”

The FAA does not agree with the dissenting opinion. The lack of a “specific” FAR/JAR requirement for engine or APU starting on the ground does not mean that engine and APU starting need not be addressed prior to granting airworthiness approval. Section 25.1309(a) requires that “equipment, systems, and installations whose functioning is required...must be designed to ensure that they perform their intended functions under any foreseeable operating condition.” Regardless of this or any other “non-specific” requirement related to engine and APU starting, starting capability for the engines and APU is a consideration, as

the working group member notes, that is relevant to operations at high altitude airports. Also, the wording of the AC paragraph of concern, “consideration should be given to any other systems whose operation may be sensitive to, or dependent upon airport altitude, such as: engine and APU starting, passenger oxygen, autopilot, autoland, autothrottle system thrust set/operation,” identifies these items as items that should be considered in the context of approval to operate from high altitude airports, not in reference to any specific part 25 requirement. Therefore, the references in paragraph 3a(8)(v) to engine and APU starting have been retained in the proposed revision to AC 25-7A.

Proposed Revisions to AC 25-7A

The guidance provided in the following proposed revision to AC 25-7A has been harmonized with that of the JAA, and provides a method of compliance that has been found acceptable to both the FAA and JAA.

This proposed revision should not be confused with other proposed revisions to AC 25-7A for which the FAA may currently be seeking comments. The revisions proposed in this notice address guidance material associated with the policies and certification approval practices relative to altitude/temperature extrapolation of takeoff performance data.

1. Replace existing paragraphs 3a(8) through 3a(9) with the following:

3. Proof of Compliance.

(8) Expansion of Takeoff and Landing Data for a Range of Airport Elevations.

(i) These guidelines are applicable to expanding Airplane Flight Manual takeoff and landing data above and below the altitude at which the airplane takeoff and landing performance tests are conducted.

(ii) Historically, limits have been placed on the extrapolation of takeoff data. In general, takeoff data could be extrapolated 6,000 feet above and 3,000 feet below the test field elevation when proven testing and data reduction methods were used. For extrapolations beyond these limits, a 2 percent takeoff distance penalty was to be applied for every additional 1,000 feet extrapolation. Such limitations were generally not applied to extrapolation of landing data, provided the effect of the higher true airspeed on landing distance was taken into account.

(iii) Considerably more experience has since been gained both in terms of modeling airplane and propulsion system (i.e., turbine engines and propellers, where appropriate) performance and in verifying the accuracy of these models for determining high (and low) altitude takeoff and landing performance. This experience has shown that the soundness of the extrapolation is primarily a function of the accuracy of the propulsion system performance model and its integration with the airplane drag model. The basic aerodynamic characteristics of the airplane do not change significantly with altitude or ambient temperature, and any such effects are readily taken into account by standard airplane performance modeling practices.

(iv) As a result, with installed propulsion system performance characteristics that have been adequately defined and verified, airplane takeoff and landing performance data obtained at one field elevation may be extrapolated to higher and lower altitudes within the limits of the operating envelope without applying additional performance

conservatisms. It should be noted, however, that extrapolation of the propulsion system data used in the determination and validation of propulsion system performance characteristics is typically limited to 3,000 feet above the highest altitude at which propulsion system parameters were evaluated for the pertinent power/thrust setting. (See paragraph 9 of this AC for more information on an acceptable means of establishing and verifying installed propulsion system performance characteristics.)

(v) Note that certification testing for operation at airports that are above 8,000 feet should also include functional tests of the cabin pressurization system in accordance with paragraph 87b(3) of this AC. Consideration should be given to any other systems whose operation may be sensitive to, or dependent upon airport altitude, such as: engine and APU starting, passenger oxygen, autopilot, autoland, autothrottle system thrust set/operation.

2. *Replace paragraph 9 in its entirety with the following:*

9. General - § 25.101

a. Explanation--Propulsion System Behavior. Section 25.101(c) requires that airplane “performance must correspond to the propulsive thrust available under the particular ambient atmospheric conditions, the particular flight conditions,....” The propulsion system’s (i.e., turbine engines and propellers, where appropriate) installed performance characteristics are primarily a function of engine power setting, airspeed, propeller efficiency (where applicable), altitude, and ambient temperature. The effects of each of these variables must be determined in order to establish the thrust available for airplane performance calculations.

b. Procedures.

(1) The intent of this testing is to develop a model of propulsion system performance that covers the approved flight envelope. Furthermore, it should be shown that the combination of the propulsion system performance model and the airplane performance model are validated by the takeoff performance test data, climb performance tests, and tests used to determine airplane drag. Installed propulsion system performance characteristics can be established via the following tests and analyses:

(i) Steady-state engine power setting vs. thrust (or power) testing. Engines should be equipped with adequate instrumentation to allow the determination of thrust (or power). Data should be acquired in order to validate the model, including propeller-installed thrust, if applicable, over the range of power settings, altitudes, temperatures, and airspeeds for which approval is sought. Although it is not possible to definitively list or foresee all of the types of instrumentation that might be considered adequate for determining thrust (or power) output, two examples used in past certification programs are: (1) engine pressure rakes, with engines calibrated in a ground test cell, and (2) fan speed, with engines calibrated in a ground test cell and the calibration data validated by the use of a flying test bed. In any case, the applicant should substantiate the adequacy of the instrumentation to be used for determining the thrust (or power) output.

(ii) Lapse rate takeoff testing to characterize the behavior of power setting, rotor speeds, propeller effects (i.e., torque, RPM, and blade angle), or gas temperature as a function of time, thermal state, or airspeed, as appropriate. These tests should include the operation of an Automatic Takeoff Thrust Control System (ATTCS), if applicable, and should cover the range of power settings for which approval is sought.

(A) Data for higher altitude power settings may be acquired via overboost (i.e., operating at a higher than normal power setting for the conditions) with the consent of the engine and propeller (when applicable) manufacturer(s). When considering the use of overboost on turbopropeller propulsion system installations to simulate higher altitude and ambient temperature range conditions, the capability to achieve an appropriate simulation should be evaluated based on the engine and propeller control system(s) and aircraft performance and structural considerations. Engine (gearbox) torque, rotor speed, or gas temperature limits, including protection devices to prohibit or limit exceedances, may prevent the required amount of overboost needed for performance at the maximum airport altitude sought for approval. Overboost may be considered as increased torque, reduced propeller speed, or a combination of both, in order to achieve the appropriate blade angle for the higher altitude and ambient temperature range simulation. Consideration for extrapolations will depend on the applicant's substantiation of the proper turbopropeller propulsion system simulated test conditions.

(B) Lapse rate characteristics should be validated by takeoff demonstrations at the maximum airport altitude for which takeoff approval is being sought. Alternatively, if overboost (see paragraph (A) above) is used to simulate the thrust setting parameters of the maximum airport altitude for which takeoff approval is sought, the takeoff demonstrations of lapse rate characteristics can be performed at an airport altitude up to 3,000 feet lower than the maximum airport altitude.

(iii) Thrust calculation substantiation. Installed thrust should be calculated via a mathematical model of the propulsion system, or other appropriate means, adjusted

as necessary to match the measured inflight performance characteristics of the installed propulsion system. The propulsion system mathematical model should define the relationship of thrust to the power setting parameter over the range of power setting, airspeed, altitude, and temperature for which approval is sought. For turbojet airplanes, the propulsion system mathematical model should be substantiated by ground tests in which thrust is directly measured via a calibrated load cell or equivalent means. For turbopropeller airplanes, the engine power measurements should be substantiated by a calibrated dynamometer or equivalent means, the engine jet thrust should be established by an acceptable engine model, and the propeller thrust and power characteristics should be substantiated by wind tunnel testing or equivalent means.

(iv) Effects of ambient temperature. The flight tests of paragraph 9b(1)(i) above will typically provide data over a broad range of ambient temperatures. Additional data may also be obtained from other flight or ground tests of the same type or series of engine. The objective is to confirm that the propulsion system model accurately reflects the effects of temperature over the range of ambient temperatures for which approval is being sought (operating envelope). Because thrust (or power) data can usually be normalized versus temperature using either dimensionless variables (e.g., theta exponents) or a thermodynamic cycle model, it is usually unnecessary to obtain data over the entire ambient temperature range. There is no need to conduct additional testing if:

(A) The data show that the behavior of thrust and limiting parameters versus ambient temperature can be predicted accurately; and

(B) Analysis based upon the test data shows that the propulsion system will operate at rated thrust without exceeding propulsion system limits.

(2) Extrapolation of propulsion system performance data to 3,000 feet above the highest airport altitude tested (up to the maximum takeoff airport altitude to be approved) is acceptable, provided the supporting data, including flight test and propulsion system operations data (e.g., engine and propeller control, limits exceedance, and surge protection devices scheduling), substantiates the proposed extrapolation procedures.

Considerations for extrapolation depend upon an applicant's determination, understanding, and substantiation of the critical operating modes of the propulsion system. This understanding includes a determination and quantification of the effects that propulsion system installation and variations in ambient conditions have on these modes.

Issued in Renton, WA on August 9, 2001.

/s/ Ali Bahrami
Acting Manager, Transport Airplane Directorate
Aircraft Certification Service